



# **Mechanical Aerospace Ground Equipment (MAGE)**

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# MAGE Top Level Requirements



- **Provide all Necessary MAGE, Fixtures, Tooling, and Adapters For Safe Handling, Testing and Transportation of FAME Flight Hardware During All Phases of Assembly, Integration, Test, Transportation, and Field Operations**
- **MAGE Design Safety Factors, NDE, and Proof Testing Comply With NRL and Range Safety Requirements; Factors of Safety:**

Type	Yield FOS	Ultimate FOS	Proof Test Factor
Handling Equipment	3.0	5.0	2.0
Lifting Equipment	3.0	5.0	2.0
Work Stands	2.0	3.0	1.5

- **FAME Flight Hardware Shall Be Protected During Ground Handling and Transportation So That the Environmental Conditions Do Not Exceed Flight or Orbital Conditions**
- **Use Existing MAGE Wherever Possible to Reduce Cost**



# List of Required MAGE

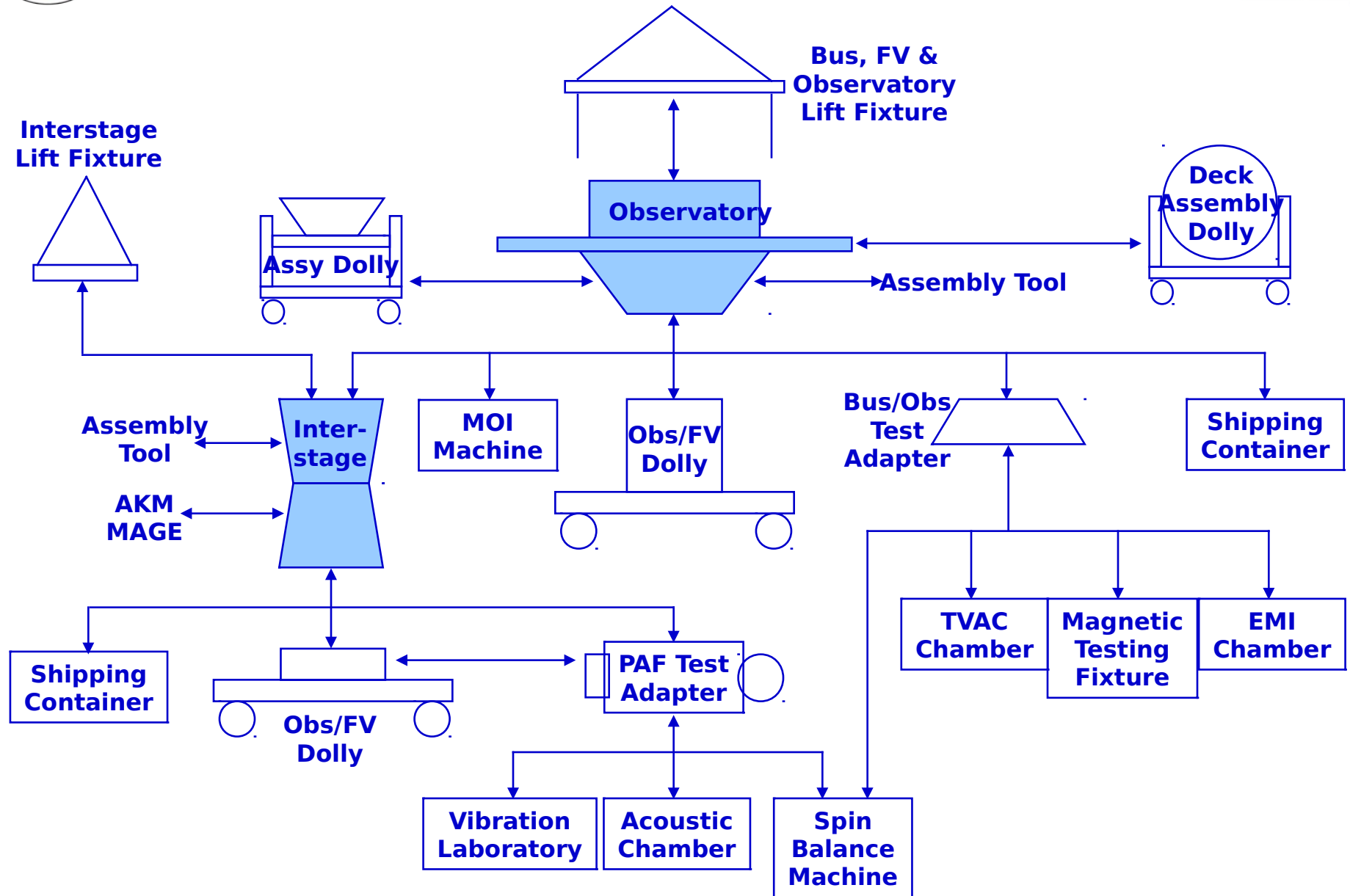


MAGE Item	Existing	Modify Existing	New Design	Comments
Bus Assembly Tool		X		Modify ICM APDA Adapter Tool
Interstage Assembly Tool		X		Modify ICM APDA Adapter Tool
Honeycomb Panel Templates			X	Direct From Panel Drawings
RCS Deck & Bus Dolly		X		Adapter Plate on WindSat Dolly
Electronics Deck Dolly		X		Adapter Plate on WindSat Dolly
Observatory & FV Dolly	X			From IMAGE/MAP Program
Bus/Observatory/FV Lift Fixture			X	
Interstage Lift Fixture			X	
AKM MAGE (Dolly, Lift, Ship)	X			Available From AKM Vendor
Magnetic Balance Fixture	X			Successfully Used For WindSat
MOI Machine Fixture			X	Also For Axial CG Measurement
Bus/Observatory Test Adapter	X			From Clementine Program
Flight Vehicle Test Adapter	X			From LV Provider
Wire Harness Mock Up			X	
Component Mass Simulators			X	For Engineering Model Testing
Thruster & Tank Covers			X	Protective Covers
Solar Array Covers			X	Protective Covers
Star Tracker Covers			X	Contamination Covers
Antenna Hats (Also RF Coupler)			X	Based Upon Many Previous
Interstage Shipping Container	X			Will Need Adapter
Observatory Shipping Container	X			May Need Adapter

Propellant, Pressurant, & AKM MAGE Covered in RCS Section



# MAGE Interfaces



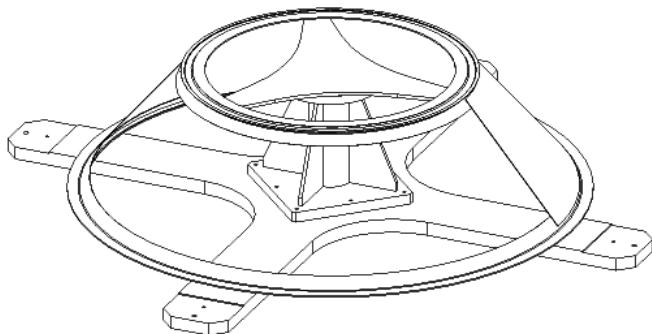


# MAGE Design Trades

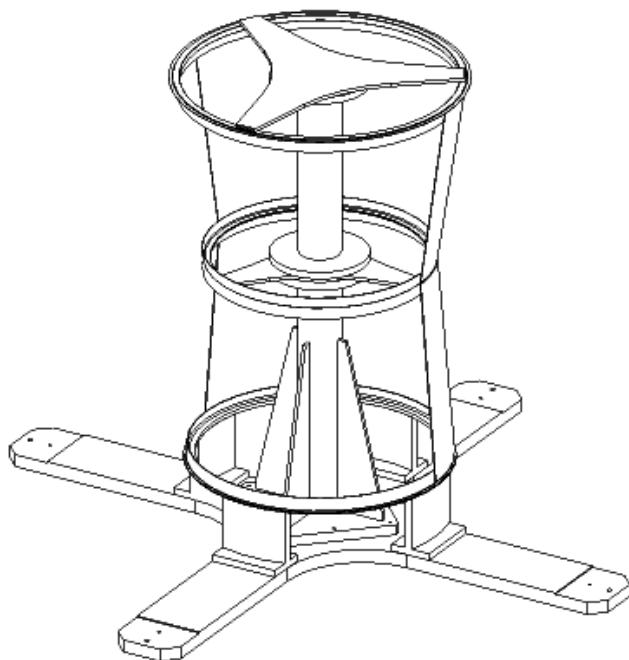


- **Item: FAME Observatory Shipping Container**
  - **Trade: Use Existing, or Design and Build New Container**
  - **Issues: Large Containers Expensive to Design and Build, No Existing NRL Assets in the Size Range Required**
  - **Resolution: Arrange for Use of the XTE/TRMM/MAP Spacecraft Shipping Container Through the Explorers Office at NASA Goddard**
  
- **Item: FAME Electronics Deck Handling Dolly**
  - **Trade: Design/Build Custom or Modify Existing**
  - **Issues: Handling and Providing Adequate Access to Large (108" Diameter) FAME Electronics Deck**
  - **Resolution: Make an Adapter and Purchase Longer Main Beams for Existing Flotron Dolly**

# Bus and Interstage Assembly Tools



**Bus Structure Assembly Tool**

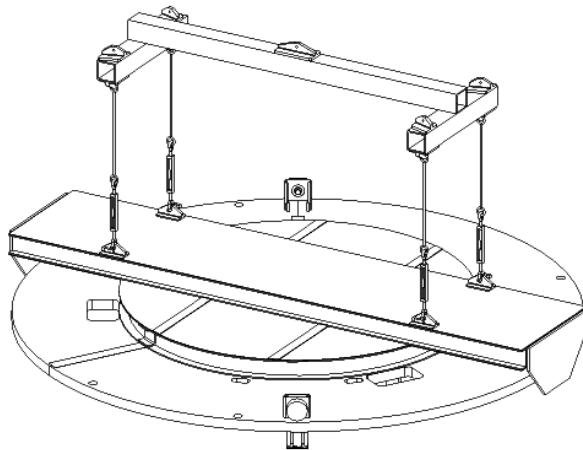
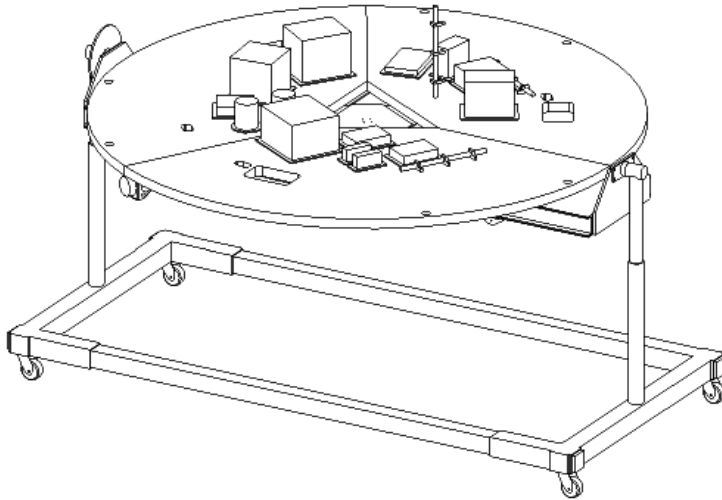


**Interstage Structure Assembly Tool**

- **Purpose: Enable the Rapid and Accurate Assembly of the Bus and Interstage Primary Structure**
- **Requirements:**
  - **Hold Rings at Proper Station and Orientation**
  - **Design Includes Features for Height and Angular Adjustment (Using Shims)**
  - **Design Is Compatible With the Use of Existing NRL Optical Inspection Tooling**
  - **Design Allows for Ready Access to All Areas of Assembly**
- **Design Implementation Utilizes Portions of an Existing Fixture**



# E-Deck Dolly and Lift Fixture

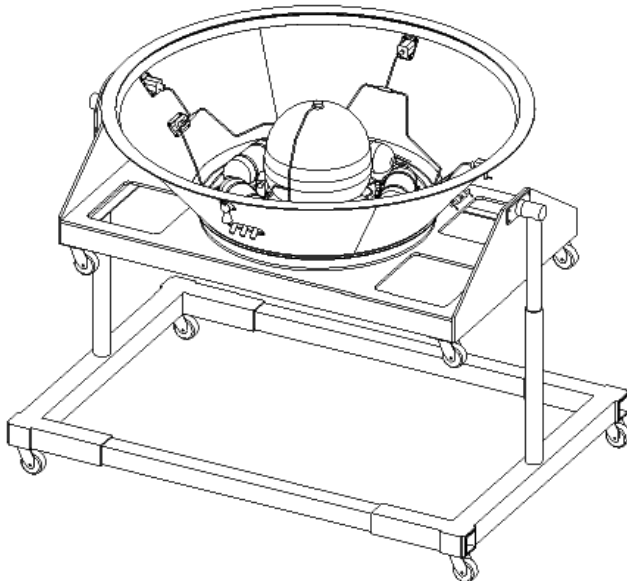
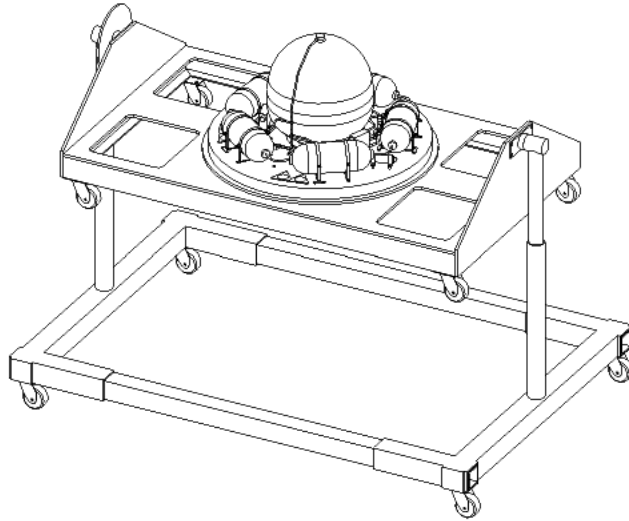


**Electronics Deck Lifting Configuration**

- **Purpose: Provide Method for Handling and Accessing Both Sides of Electronics Deck**
- **Requirements:**
  - **Rigidly Hold All 3 Segments of the Electronics Deck (Ø 108")**
  - **Adapter Between Existing Dolly and FAME E-Deck Doubles as a Lift Fixture for Installing Deck on FAME Bus**
  - **Include Provision for Locking Rotation at Various Angles**
  - **500 Lb Rated Capacity**
  - **Factors of Safety:**
    - **Yield: 3:1**
    - **Ultimate: 5:1**
  - **Proof Test 2X Rated Load**



# RCS Deck Dolly



- **Purpose: Provide Method for Handling and Accessing RCS Deck During RCS Subsystem Integration**
- **Requirements:**
  - **Cleanroom Compatible**
  - **Allow for Access to All Areas of RCS Deck**
  - **Designed to Accommodate Bus Structure for Thruster Integration**
  - **Include Provision for Locking Rotation at Various Angles**
  - **250 Lb Rated Capacity**
  - **Factors of Safety:**
    - **Yield: 3:1**
    - **Ultimate: 5:1**
  - **Proof Test 2X Rated Load**





# Observatory/Flight Vehicle Dolly

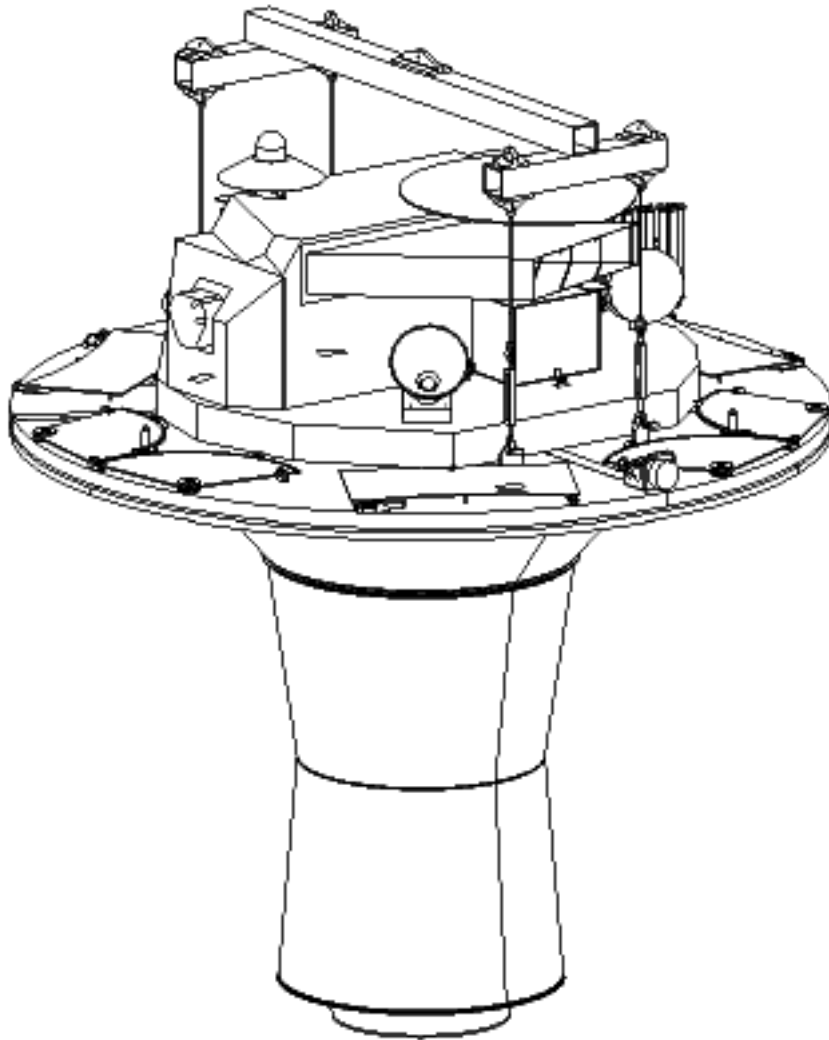


Have Arranged for Use of the  
IMAGE/MAP Handling Dolly (Above)  
Through the NASA GSFC Explorers Office

- **Purpose: Handling Observatory and Flight Vehicle During System I&T and Field Ops**
- **Requirements:**
  - **Cleanroom Compatible**
  - **Allows for Transportation Between A59 Test Facilities**
  - **Provide for Access to Install Components, Cable Up, Attach Lift Fixture**
  - **Designed to Accommodate Both Observatory and Flight Vehicle (Using Adapter)**
  - **Require 2500 Lb Capacity**
  - **Factors of Safety:**
    - **Yield: 3:1**
    - **Ultimate: 5:1**
  - **Proof Test 2X Rated Load**



# Bus/Observatory/FV Lift Fixture

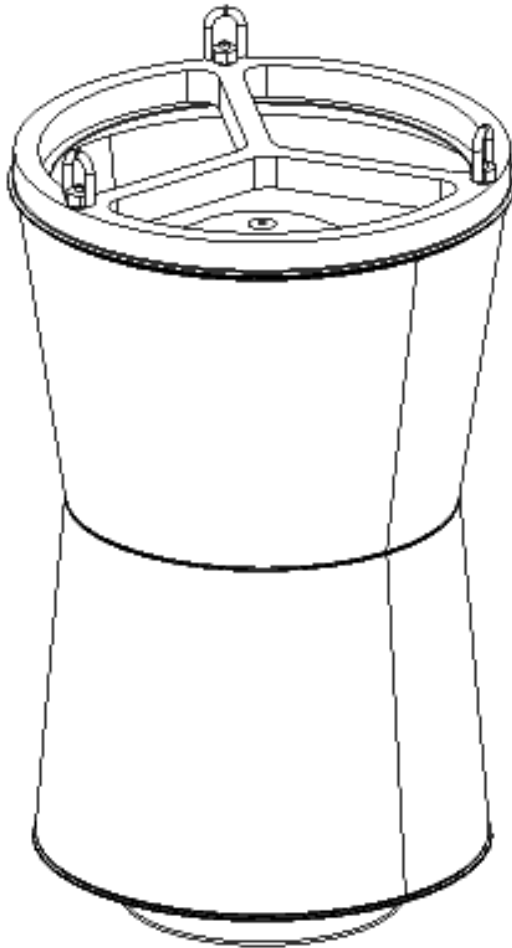


**Flight Vehicle Lifting Configuration**

- **Purpose: Provide Method for Safely Lifting Bus, Observatory, and Flight Vehicle**
- **Requirements:**
  - **Cleanroom Compatible**
  - **Design, Analysis, Testing, and Inspection Complies With NRL and Range Safety Requirements**
  - **Does Not Interfere With Bus or Instrument Components**
  - **2500 Lb Rated Capacity**
  - **Factors of Safety:**
    - **Yield: 3:1**
    - **Ultimate: 5:1**
  - **Proof Test 2X Rated Load Initial and Within 1 Year of Use at Range**



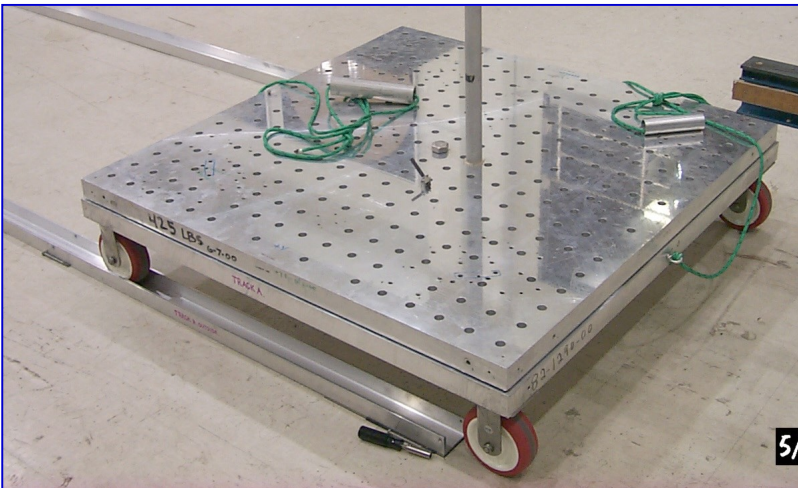
# Interstage Lift Fixture



- **Purpose: Provide Method for Safely Lifting Interstage**
- **Requirements:**
  - **Used in Conjunction With “Clam-Shell” GSE Clamp**
  - **Design, Analysis, Testing, and Inspection Complies With NRL and Range Safety Requirements**
  - **1500 Lb Rated Capacity**
  - **Factors of Safety:**
    - **Yield: 3:1**
    - **Ultimate: 5:1**
  - **Proof Test 2X Rated Load Initial and Within 1 Year of Use at Range**



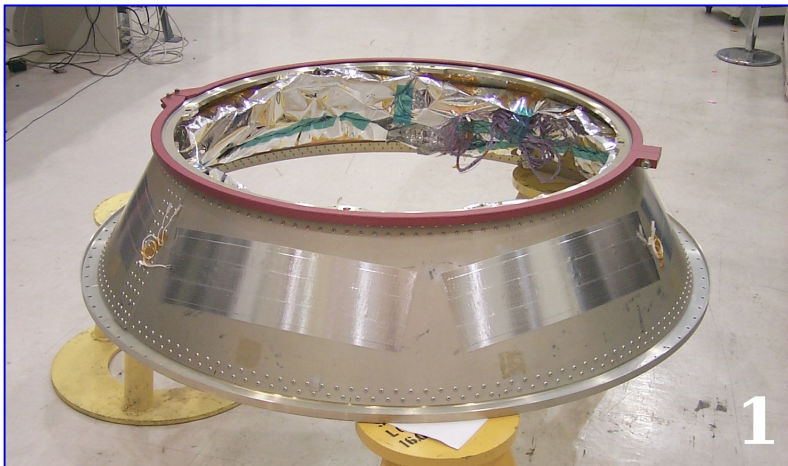
# Magnetic Balance Test Fixture



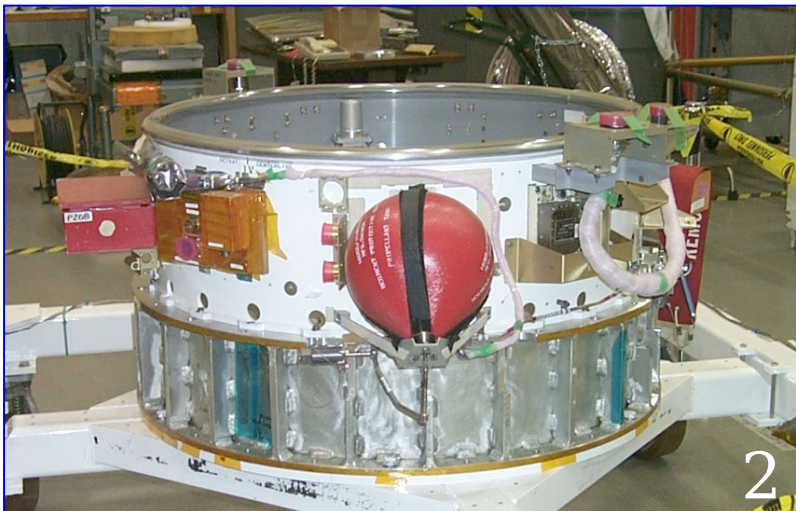
- **Purpose: Provide Suitable Fixture for Performing Observatory Magnetic Balance in NRL Building A59**
- **Requirements:**
  - **Repeatably Translate Observatory to and Away From an Array of Magnetometers**
  - **Enable Full Rotation of the Observatory Around the Z-Axis in 15 Degree Steps**
  - **1250 Lb Rated Capacity**
  - **Factors of Safety:**
    - **Yield: 3:1**
    - **Ultimate: 5:1**
  - **Proof Test 2X Rated Load**



# Observatory and FV Test Adapters



- **Purpose: Provide Interface Between Flight Hardware and Test Equipment**
- **Requirements:**
  - **Provide Suitable Adapter for Each of the Following Tests:**
    - **EMI, Magnetic Balance (1)**
    - **Thermal Balance, TVAC (1)**
    - **Spin Balance (1 & 2)**
    - **Modal, Loads (2)**
    - **Vibration, Acoustic (2)**
    - **Pyroshock (2)**
  - **Stress Analysis and/or Proof Load Required for Each Test Configuration**
  - **Test Adapter 2 (3712A PAF) Provided by Boeing**





# Interstage Shipping Container



**Container Shown Is an  
Existing and Available NRL  
Asset**

- **Purpose: Provide Method for Safe Transportation of Flight Interstage (Not Including AKM)**
- **Requirements:**
  - **Protect Flight Hardware Against Damage in Handling and Shipping**
  - **Sealed to Prevent Moisture and Contamination Entry**
  - **Shock Isolation System**
  - **Shock, Temperature, and Humidity Monitoring System**



# Observatory Shipping Container



**FAME Has Arranged for Use of the  
XTE/TRMM/MAP Shipping Container (Above)  
Through the NASA GSFC Explorers Office**

- **Purpose: Provide Method for Safe Transportation of FAME Observatory to Launch Site (and GSFC as Required)**
- **Requirements:**
  - **Protect Flight Hardware Against Damage in Handling and Shipping**
  - **Sealed to Prevent Moisture and Contamination Entry**
  - **Requires Suitable Interface for FAME Observatory**
  - **Shock Isolation System**
  - **Shock, Temperature, and Humidity Monitoring System**
  - **Environmental Control System Including HEPA Filtered Air**
  - **Provisions Nitrogen Purge**



# Issues and Status



- **FAME MAGE Status**
  - **33% Existing and Available to Support FAME**
  - **19% Modifications to Existing**
  - **48% New Design**
- **MAGE Schedule Milestones**
  - **Bus and Interstage Assy Tools Ready 11/2002**
  - **E-Deck and RCS Deck Dollies Ready 12/2002**
  - **Observatory Dolly From GSFC 1/2003**
  - **Observatory Lift Fixture Ready 1/2003**
  - **Observatory Shipping Container Ready 5/2004**
- **Open Issues/Future Work**
  - **Observatory Lift Fixture Design:**
    - **CG Location When Lifting Observatory Without Interstage/AKM**
  - **Need an Adapter to MOI Machine for Measuring FAME Observatory Lateral Moments of Inertia**
    - **It Is Anticipated That the Same Fixture Will Be Used for Observatory Axial CG Measurement**